$$\frac{Ar}{AA'} + \frac{Bs}{BB'} + \frac{Ct}{CC'} = 1.$$

Let now two other chords be drawn from A making with $A\alpha$ very small angles, so as to form with it the edges of a very small pyramid, and let other chords parallel to them be drawn from B and C, forming also with $B\beta$ and $C\gamma$ the edges of two other small pyramids. Imagine a sphere fixed in space, from whose centre are drawn three lines parallel to the three chords drawn from A, or from B, or from C, and conceive the surface of the pyramid, of which they are the edges, to penetrate that of the sphere; then will the attractions of the three pyramids, reduced each to the direction of the axis passing through its vertex, be to Ar, Bs, Ct as the intercepted surface of the sphere to the square of its radius; and therefore the sum of each of those attractions, divided respectively by AA′, BB′, CC′, will be to unity in the same ratio. Conceive pyramids thus related to be multiplied indefinitely, and the spheroid will be exhausted at once from each of the three points A, B, C, while half the surface of the sphere is exhausted by the parallels drawn from its centre. Hence it appears that the sum of the whole attractions at A, B, C, divided respectively by AA′, BB′, CC′, is to unity as the surface of a hemisphere to the square of its radius, or as 2π to 1; and therefore

$$\frac{A_0}{a} + \frac{B_0}{b} + \frac{C_0}{c} = 4\pi.$$

January 22.

REV. JAMES H. TODD, D. D., Vice-President, in the Chair.

Mr. W. H. Hudson exhibited specimens of Irish books, now in the course of publication in Cork, which are lithographed. He described the advantages which that process presents over types, for composition in the Irish character.

Dr. Kane read a paper on the Chemical Composition of the different kinds of fuel found in Ireland.

Although this country is recognized as destitute of the great development of the coal strata, which has proved so important an element in the industrial progress of Great Britain, yet there are known to exist several coal districts, some bituminous and some anthracitous, as well as deposits of wood coal, which, with the great extent of turf-bog occupying the surface in many places, may be considered as stores of fuel, available and sufficient for the supply of the interior of the country for a very long time. In order, however, to be able to calculate the economic value, or calorific power of any of these Irish fuels, and so to compare them with the corresponding fuels in other countries, it was necessary to know their elementary composition; and hence, in order to lay the basis of a true estimate of the worth of our native fuels, Dr. Kane commenced the series of analyses which formed the present communication.

In order to exhibit all the relations of the composition of these fuels, that might be useful in drawing practical conclusions, Dr. Kane adopted two distinct modes of analysis: one, exhibiting the real elementary composition; the other, which he terms the practical analysis, representing the relation of the ashes, and of the fixed and volatile constituents of the fuel. He also in each case ascertained the quantity of oxygen which the fuel was capable of taking up, in order to be perfectly consumed. As the analysis of fuels is known to present some difficulty, it is necessary to mention briefly the precautions taken in order to secure accurate results.

The point first determined was in each case the quantity of ashes present. To effect this a certain weight of the fuel was burned in a current of hot air, until all traces of organic material disappeared. The residual ash was then weighed.

To conduct the determination of the carbon and the hydrogen of the fuels, the methods were varied according to the nature of the substance, with turf, lignite, and the bituminous coals. The proper weight of the material having

been dried at 212° F., was in some cases mixed with chromate of lead, and the analysis conducted in the ordinary manner; in other cases, the substance was mixed with black oxide of copper, and some chlorate of potash having been placed in the end of the analysis tube, the operation was conducted in the usual way to near the termination, when the chlorate of potash being heated, a stream of oxygen gas passed through the apparatus, and burned out the last traces of the organic substances.

These two modes gave almost identical results with the same fuel, and there is no necessity for distinguishing amongst the analyses, of which the results follow, those that were done in the one way or in the other.

It was found, however, that the anthracite could not be perfectly analysed by either of these modes: the difficulty of burning away the last portions of the carbon was so great. Hence a totally different plan was adopted for that variety of fuel. An analysis tube of Bohemian glass having been taken about a foot long, the substance to be analysed was placed in a little boat of platina foil, and introduced into the tube near one end. To this end was fitted a tube containing dry chloride of calcium to collect the water; then the potash absorbing apparatus, then another potash absorbing apparatus, and finally a tube containing dry potash. These three were for the purpose of separating the carbonic acid perfectly from the excess of oxygen, and also to prevent the oxygen from carrying away any moisture from the potash liquor. The other end of the tube was connected with a gazometer full of pure oxygen gas, which, streaming over a large surface of fused chloride of calcium, was rendered perfectly dry. The apparatus being so adjusted, the analysis tube was heated to redness by charcoal, so that the oxygen gas passed through five or six inches of red hot tube before coming to the ignited anthracite. The analysis was thus conducted, as it were, with the hot blast, and the combustion was in all cases quite perfect. This kind of process would

only answer with such fuels as anthracite, which contains very little hydrogen, but with those it succeeded perfectly.

Such were the means taken for the organic elementary analysis. The nitrogen was not separately determined, as the results were only required for economic calculations, and the minute trace of nitrogen does not there become important. Its weight (in all cases very small) is included in the number assigned to oxygen in the results of the analyses.

The practical analysis was conducted by very strongly igniting a weighed portion of the fuel in a platinum crucible the cover of which fitted so closely as to prevent any sensible combustion of the residual coke. The weight of ashes being known, the pure coke was then found.

The determination of the reducing power of the fuel by means of litharge, requires very considerable care in practice in order to get satisfactory results. The principal point to be attended to, is to use a roomy crucible, and to apply a quick and strong heat, so that the litharge shall at once run thin. When this is done, the results with the same fuel are very uniform, and with different fuels are fully comparable; although in no case is so much lead got as should be in theory obtained from the conversion of the carbon and hydrogen of the fuel, minus its oxygen, into carbonic acid and water. The deficiency is usually proportional to the quantity of volatile matter in the fuel, and is not in any case large, provided proper care be taken. Hence Dr. Kane considers, and the opinion is also held by Berthier, that the result is so near the truth as to be quite available as a practical and ready measure of the heating power of the fuel.

The general nature of the inquiry, and the methods employed, having been thus described, it is only necessary to add the numerical results of the analysis.

In order that the results might represent as far as practicable the average composition of the fuel, in each case rather a large mass was broken up, and its coarse powder

well mixed. Some ounces of this were then reduced to impalpable powder, and from this all the portions to be operated upon were taken.

I. ANTHRACITES OF THE SOUTH OF IRELAND.

Three specimens of this kind of coal were analysed:

1, from the Rushes Colliery, Queen's County;

2, „ the Pollough Vein, Castlecomer, Co. Kilkenny;

3, „ the Sweet Vein, Kanturk, County Cork.

The anthracites have no tendency to froth or cake in cokeing. They give off little or no inflammable gas on being ignited, but usually the masses break up quite small, especially if the heat be suddenly applied. The ashes are almost always red, owing to peroxide of iron remaining after the combustion of the iron pyrites, which the anthracite generally contains.

Rushes anthracite—0.375 grammes gave:

Water	0.118
Carbonic acid	1.238
Light red ashes . . .	0.014

The Pollough anthracite. 0.364 grammes gave:

Water	0.079
Carbonic acid	1.086
Brown ashes	0.036

The Sweet Vein anthracite—0.293 grammes gave:

Water	0.098
Carbonic acid	0.928
0.305 gave . . .	0.026 ashes, white.

These coals consisted, therefore, of:

	Rushes.	Pollough.	Sweet Vein.
Carbon	90.04	81.36	86.37
Hydrogen . . .	3.50	2.41	3.71
Oxygen . . .	2.73	6.34	1.40
Ashes	3.73	9.89	8.52
	100.00	100.00	100.00

Of these coals the Sweet Vein was perfectly free from sulphur; the Rushes coal contained but a minute trace; but the Pollough coal contained a good deal, and as the sulphurous acid produced during its combustion should be absorbed by the potash, and counted as carbonic acid in the analysis, it was necessary to correct the above result by a direct determination of the sulphur. For this purpose 3.526 grammes of the coal were boiled with aqua regia, and the liquor precipitated by chloride of barium. The sulphate of barytes obtained weighed 1.589 grammes, corresponding to 45.07 per cent., containing 6.18 of sulphur.

Now, 6.18 sulphur give 12.36 sulphurous acid, and subtracting that from the carbonic acid obtained in the elementary analysis, then converting the sulphur into bisulphuret of iron, and subtracting the pyrites from the ash, there comes out, as the true composition of the Pollough coal:

Ash, free from iron . . .	2.19	
Bi-sulphuret of iron . . .	11.58	
Carbon	75.42	giving of pure anthracite 86.23.
Hydrogen	2.41	
Oxygen	8.40	
	100.00	

It is interesting to contrast the composition of the really organic part of these three varieties of coal.

	Rushes.	Pollough.	Sweet Vein.
Carbon	93.53	87.46	94.39
Hydrogen . . .	3.63	2.79	4.05
Oxygen . . .	2.84	9.75	1.56
	100.00	100.00	100.00

By the practical mode of analysis these coals were found to give, per cent.:

	Rushes.	Pollough.	Sweet Vein.
Volatile matter . .	9.85	10.40	10.35
Pure coke . . .	86.42	79.71	81.13
Ashes	3.73	9.89	8.52
	100.00	100.00	100.00

The result of ignition with litharge was, that

One part of Rushes coal gave . 31.8 of lead.
Pollough . . . . . 26.7 „
Sweet Vein . . . . . 29.0 „

Hence they correspond respectively.

100 parts of Rushes to . . 93.5 of pure carbon.
100 „ Pollough . . 73.5 „
100 „ Sweet Vein . 85.3 „

And in average 100 parts of Irish anthracite may be considered to possess a calorific power equal to 84 parts of pure carbon.

II. COAL OF THE CONNAUGHT BASIN.

The coals examined were all from the collieries of Brahlieve mountain, forming the western division of the Lough Allen coal field. The specimens were furnished through the kindness of Colonel Jones, member of the Shannon Commission. The results were as follow:

AUGHABEHY COAL.

A rich, black coal, easily broken. Sp. gr. 1.274. When heated, it gives off a good deal of inflammable gas, and leaves a light grey, porous, coherent coke.

Its elementary analysis was effected:

0.472 grammes gave:
Carbonic acid . . . . . 1.379 grammes.
Water . . . . . 0.265 „

0.921 grammes gave of white ashes, 0.099, or 10.75 per cent.

Hence it contained:

Carbon	79.69
Hydrogen	6.24
Oxygen	3.32
Ashes	10.75
	100.00

ROVER COAL.

This coal is rather brown in aspect, and splits easily into cubical fragments. On ignition it gives out gas, but does not froth. Its coke is porous, slightly coherent.

Its elementary analysis was:

3.196 grammes gave . . . 0.237 of ashes, equivalent to 7.41 per cent.

0.489 gramme gave:

Water	0.216
Carbonic acid	1.453

Hence it contained:

Carbon	81.04
Hydrogen	4.91
Oxygen	6.64
Ashes	7.41
	100.00

The practical analysis of these two coals gave the following results:

Aughabehy Coal.—13.418 grammes gave on ignition 10.340 of coke.

Rover Coal.—14.300 gave on ignition 11.770 of coke.

Hence they consisted of:

	Aughabehy.	Rover.
Volatile matter	23.10	17.70
Pure coke	66.15	74.89
Ashes	10.75	7.41
	100.00	100.00

Specimens of coal from the Celtnaveena and the Meenashama collieries were also examined in this manner, with the following results:

Celtnaveena Coal.—14.772 grammes gave by ignition 11.960 of coke.

1.091 gramme gave 0.164 of white ashes.

Meenashama Coal.—6.280 grammes gave 5.095 coke.

3.778 gave 0.742 of ashes.

Hence they consist of—

	Celtnaveena.	Meenashama.
Volatile matter . . .	19.10	18.90
Pure coke	65.87	61.46
Ashes	15.03	19.64
	100.00	100.00

Each of these varieties of coal was examined as to the quantity of oxygen it absorbed by reducing litharge.

1 part of Aughabehy coal produced 26 parts of lead.

1 part of Rover coal produced 28½ parts of lead.

1 part of Celtnaveena coal gave 26 of lead.

1 part Meenashama coal gave 25 of lead.

100 parts are therefore equivalent

Of Aughabehy to .	77	parts of pure carbon.
Rover	84	,,
Celtnaveena . .	77	,,
Meenashama . .	73	,,

These coals are similar in appearance to the Aughabehy, but are more slaty. When ignited they give off inflammable gas, but do not froth. Their coke is dense.

It is thus seen that the Aughabehy is the most bituminous of these coals, whilst the Rover is the least so, and that in fact the latter approaches closely in its composition to the anthracite of the Munster coal field.

III. COAL ON THE TYRONE BASIN.

Of this locality two kinds of coal were examined, from opposite sides of the field, the new Drumglass Colliery, and the colliery at Coal Island.

COAL ISLAND COAL.

It is slaty in structure, dull coloured; sp. gr. 1.267. On ignition it gives off much gas, froths, and leaves a very porous coke.

2.814 gave 0.328 of ashes almost white.

8.830 grammes gave after ignition 5.390 of coke.

It hence consisted of

Volatile matter	38.96
Pure coke	49.39
Ashes	11.66
	100.00

In its elementary analysis, 0.563 gramme gave:

Water	0.297
Carbonic acid	1.426

Whence results the composition

Carbon	69.08
Hydrogen	5.86
Oxygen	13.41
Ashes	11.65
	100.00

On ignition with litharge, one part of this coal gave 26½ of lead, hence 100 parts correspond to 78 of pure carbon.

NEW DRUMGLASS COLLIERY.

This coal is brilliant, black, friable, frequently mixed with pyrites, which oxidize on exposure to the air. Its ashes are consequently reddish. On ignition it gives off much gas, froths, and produces a light porous coke. Its practical analysis was as follows:

1.977 grammes gave of brown ash 0.342.

11.540 gave on ignition 5.920 of coke. It consisted hence of—

Volatile matter	48.70
Pure coke	34.00
Ashes	17.30
	100.00.

When ignited with litharge, one part produced 22 parts of lead. 100 parts of it are therefore equivalent to 65 parts of pure carbon.

IV. COAL OF THE ANTRIM DISTRICT.

The coal of Ballycastle is dull, black; sp. gr. 1.279. On ignition it gave out much gas, frothed, and left a porous coke. On its practical analysis it gave in 100 parts

Volatile matter	36.96
Pure coke	45.94
Ashes	17.10

One part of it produced 25 of lead, and 100 are therefore equivalent to 71½ parts of pure carbon.

V. LIGNITES OF LOUGH NEAGH.

Having thus determined the composition, and more important practical relations of the coals from the several coal districts of Ireland, Dr. Kane proceeded to examine the nature of the deposit of lignite which is found among the tertiary beds along the southern extremity of Lough Neagh. As these investigations had solely a technical object, the silicified wood of that district did not require any notice, but only such wood-coals as were capable of use as fuel, Two specimens were examined. They retained all the structure of wood, and were of a deep brown colour. When ignited they gave off gas, which burned brilliantly, and left a dense black charcoal.

On elementary analysis, they gave the following results:

No. 1.—1.887 gave 0.163 of a reddish ash containing much iron.

0.489 grammes gave:

Water	0.262
Carbonic acid	1.050

No. 2.—3.393 grammes gave of slightly reddish ashes 0.550.

0.648 gramme gave

Water	0.429
Carbonic acid	1.220

These lignites consequently consisted of

	No. 1.	No. 2.
Carbon	58.56	51.36
Hydrogen	5.95	7.35
Oxygen	26.85	25.08
Ashes	8.64	16.21
	100.00	100.00

The results of the practical analyses were as follows:

	No. 1.	No. 2.
Volatile matter	57.70	53.70
Pure charcoal	33.66	30.09
Ashes	8.64	16.21

By ignition with litharge, No. 1 gave 19½ parts of lead, and No. 2 gave 16.7 parts. They hence were equivalent in 100 parts.

No. 1.—To 58 parts of pure carbon.

No. 2.— „ 50 „

VI. TURF.

The specimens of turf were selected from Cappoge, in Kildare, and Kilbeggan, in Westmeath, on different sides of the great Bog of Allen, and from Kilbaha, in Clare. When ignited, turf gives off inflammable gas, and leaves a light, easily combustible charcoal.

The elementary analyses were as follows:

KILBEGGAN TURF.

.383 grammes gave:

Water	0.230
Carbonic acid	0.857
Ashes	0.007

KILBAHA TURF.

3.435 grammes gave 0.277 of a light reddish ash.

0.663 gramme gave:

Water	0.378
Carbonic acid	1.243

CAPPOGE TURF.

10.566 grammes gave 0.270 of ashes.

0.500 gramme gave:

Water	0.308
Carbonic acid	0.935

From these results follow the composition:

	Kilbeggan.	Kilbaha.	Cappoge.
Carbon	61.04	51.13	51.05
Hydrogen	6.67	6.33	6.85
Oxygen	30.46	34.48	39.55
Ashes	1.83	8.06	2.55
	100.00	100.90	100.0

In the practical analysis of turf it is necessary to attend to the physical constitution of the fuel, as, even with the same chemical elements, the heating power, and the proportion of fixed and volatile parts, will vary with the denseness of texture of the fuel. Important differences exist also in the characters of the turf taken at different depths below the surface of a bog. These circumstances require to be carefully attended to in practice.

When ignited, there were obtained from specimens of light surface turf:

	Cappoge.	Kilbeggan.
Volatile matter	73.63	75,50
Pure charcoal	23.82	22.67
Ashes	2.55	1.83
	100.00	100.00

and from deep-seated turf,

	Kilbaha.	Cappoge.
Volatile matter .	72.80	70.10
Pure charcoal .	19.14	23.66
Ashes	8.06	6.24
	100.00	100.00

Of these varieties of turf it was found that on ignition with litharge,

1 part light Cappoge turf gave 13.0 of lead,
1 „ Kilbeggan turf „ 14.2 „
1 „ Kilbaha turf „ 13.8 „

and hence that 100 parts corresponded, of

Cappoge turf to 37 of pure carbon.
Kilbeggan „ 41 „ „
Kilbaha „ 40 „ „

By means of these investigations Dr. Kane trusted that the chemical nature, and economic value of the fuels of Ireland might be considered as established, and thus one step made towards a correct knowledge of the circumstances under which this country is placed as to those important materials of industry. The question as to the extent of those deposits, the real quantity of each fuel available in practice, as well as the mode in which those deposits have had their origin, pass from the domain of chemical inquiry, and hence have been left by Dr. Kane to those geological philosophers whom the Academy proudly enumerates amongst its members.

Dr. Apjohn and Mr. R. Mallet made some observations.